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(12°) DESCRIPTION OF THE INVENTION
for which a Russian Federation Patent is applied for

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(76°) Sergei Feodos'yevich Konovalov (RU), David George Morgan (GB), Andrei Borisovich Polunin (RU)
(56°) 1. USA patent number 4806928, Kl G 01V 1/00, 1989
2. FRG claim number 3912614, Kl E 21B 47/12, 1989

(54°) **A system for transmitting electrical energy and data within a column of adjoining tubes**

(57°) Essence of the invention: the system for transmitting information and electrical energy contains electrical conductors positioned along the body of the tubes, and elements of non-contact communication on the nipple and coupling. These elements take the form of transformer windings positioned in the circular channels of the adjoining tubes. The circular channels may be positioned on the butt of the coupling and the supporting surface of the nipple, on the conical threaded joints of the nipple and coupling, on the butt of the nipple and the opposite surface of the coupling, on the outer cylindrical surfaces of the nipple and coupling, or on the inner surfaces of the nipple and coupling. The transformer windings 6 may be positioned inside unconnected magnetic circuits, in which case the tubes may consist of non-magnetic material. The transformer windings may be wound around internal connected circular magnetic circuits, installed in the circular channels, in which case the tubes may consist of non-magnetic electrically conductive material.
11 columns of text, 25 illustrations.

The field of the invention is the drilling of wells, and specifically devices for non-contact transmission of energy from a source located in one of the tubes making up the column to the consumption point located in another of the tubes making up the column, for analogue transmission of information or simultaneous transmission of information and energy.
The prior art relates to a system for transmitting energy and information for drilling apparatus (1), containing electrical conductors positioned along the body of the tubes, and electrical contact communication elements on the nipple and coupling.
This system is however distinct in presenting all the shortcomings of devices using contact electrical energy.
Another prior art relates to an electrical system for transmitting energy for boreholes (2), containing electrical conductors positioned along the body of the tubes, and non-contact communication elements – a magnetic field source and a Hall transmitter – positioned on the nipple and the coupling of the adjoining tubes' lock.
The shortcomings of this system are its complex construction and poor reliability.
Figure 1 indicates the column of tubes in the electrical transmission system, in which the transformer windings are positioned in the circular channels on the butt of the coupling and on the supporting surface of the nipple. Figure 2 is a cross-section A-A of Figure 1. Figure 3 indicates a version of the electrical transmission system in which the transformer winding of the system is positioned obliquely in the circular channels of the nipple and coupling. Figure 4 indicates a version of the electrical transmission system in which the transformer winding of the system is placed within an internal unconnected magnetic circuit positioned in the circular channels of the nipple and coupling. Figure 5 indicates a version of the electrical transmission system in which the transformer winding is wound around an internal closed circular magnetic conductor and is positioned in the circular channels of the nipple and coupling. Figures 6 and 7 indicate versions of the transmission system (Figures 3 and 5) in which the outer parts of the nipple and coupling support (or of the nipple and coupling only) protrude. Figure 8 indicates one variety of Figure 3, in which the protruding part of the support provides a

reliable lock for the magnetic circuit (in the versions shown in Figures 8 and 7 a cover 30 is used to protect the winding against mechanical damage). Figure 9 indicates a variety of the version of the transmission system (Figure 5) where non-conductive tubes are used. Figure 10 indicates a closed circular magnetic circuit, around which the transformer winding is wound. Figure 11 indicates a column of tubes with an electrical transmission system, in which the transformer windings are positioned in circular channels placed in the conical threaded joints of the nipple and coupling. Figures 12 and 13 indicate different positioning of the transformer windings (as per Figure 11), with the windings placed in internal magnetic circuits. Figure 14 indicates a version of the transformer winding's internal magnetic circuit, positioned in the circular channel of the nipple (as per Figures 12 and 13). Figures 15-17 indicate a column of tubes with an electrical transmission system, in which the transformer windings are positioned in circular channels on the butt of the nipple and the opposite surface of the coupling. Figures 18-20 indicate a column of tubes with a transmission system, in which the transformer windings are positioned in circular channels placed on the outer cylindrical surfaces of the nipple and coupling. Figures 21-23 indicate a column of tubes with a transmission system in which the transformer windings are positioned in circular channels placed on the inner cylindrical surfaces of the nipple and coupling. Figures 24 and 25 indicate versions of the electrical conductors in the information and energy transmission system.

The proposed system works as follows:
The nipple 1 of one tube 2 in the column is connected with the coupling 3 of the second tube 4 by a threaded joint 5 (Figure 1). The transformer windings 6 of the system are positioned in circular channels 7 on the nipple 1 and the coupling 3.The electrical conductors 8 of the system are positioned along the body of the tubes, for example in grooves 9, where they are fixed and insulated by a compound 10.
In one version, the transformer windings 6 may be positioned obliquely in the channels 7 of the nipple 1 and coupling 3, in which case the transformer windings are fixed and insulated in the channels 7 by a compound 11. The transformer winding outlets 12 for joining to the electrical conductors 8 may pass, for example, through an aperture 13 (Figures 3-10).
In another version, the transformer windings 6 are positioned in an internal unconnected magnetic circuit 14 (Figure 4). Here, as in the previous version, the windings are fixed and insulated in the magnetic circuit 14 and channels 7 by a compound 11, and their outlets may pass through an aperture 13.
In still another version, the transformer windings 6 are wound around an internal closed circular magnetic circuit 15, which may be continuous, be wound on as ribbon or consist of ferrite. Windings thus produced are placed on the circular channels 7 of the nipple 1 and coupling 3, and fixed and insulated in the channel by a compound 11 (Figures 5-10).
Figure 6 indicates a variety of the constructive version of transformer winding. To ensure a reliable short-circuited electrical spire joint, consisting of the magnetic circuits of the nipple 1 and coupling 3, the outer parts 16 of the nipple and coupling support protrude.
Figure 9 indicates another variety of the constructive version of transformer windings.
When one or both of the pipes 2 and 4 are non-conductive, the winding 6 with an internal closed circular magnetic circuit 15 in the channel 7 positioned in the non-conductive tube should be inside an additional circular unconnected conductive core 17, the unconnected butts of which protrude above the linked surfaces.
The transformer windings 6 in the information and energy transmission system may be positioned in the circular channels 7 in the conical threaded joints 5 of the nipple 1 and coupling 3 (Figures 11-14).
Figure 11 indicates the version in which the transformer windings 6 are positioned obliquely in the circular channel 7 of the nipple 1 and coupling 3. In order for the winding 6 to be positioned in the coupling 3 in a way that makes technological sense, a combined coupling 3 with a main part and headpiece 18 may be used.
Figures 11 and 14 indicate a version in which the transformer windings 6 are positioned in internal unconnected magnetic circuits 19 and 20, similar to the magnetic circuits 14 in Figure 4. If the coupling 3 is combined, the outer circuit 19 may be a continuous circle. If the nipple 1 is continuous (non-combined), the inner magnetic circuit 20 must be sectional. For example, as shown in Figure 14, it may consist of two halves. Figure 12 indicates a version with the windings positioned in internal closed circuits 15, similar to those in Figure 10. Here, in order for a magnetic circuit to be installed, the nipple and coupling must both contain a headpiece 21.
The transformer windings 6 in an information and energy transmission system may also be positioned in the circular channels 7 on the butt of the nipple 1 and the opposite surface of the coupling 3 (Figures

3

15-17). Here, the windings 6 may be placed obliquely in the channels 7 (Figure 15) or in internal closed magnetic circuits 14 (Figure 16).

If the nipple butt and the opposite surface of the coupling are used as supports in the lock between adjoining tubes (in which case a gap will be evident at the coupling butt), the transformer windings 6 in the channels 7 may be placed in internal closed circular magnetic circuits 15 similar to those in Figure 10. In this case, in order to obtain a reliable closed conductive circuit, the inner parts of the nipple and coupling must protrude (Figure 17).

When the tubes' internal conductivity is insufficient, the winding 6 in the magnetic circuit 15 must be placed in an additional circular closed conductive core 17, the unconnected couplings of which protrude above the adjoining surface (Figure 9). If a conductive tube and a non-conductive tube then join, only one winding must be placed in the unconnected conductive core, corresponding to the circular channel of the non-conductive tube. The second winding is positioned in the circular channel of the conductive tube, without additional core.

In addition to the versions examined, the transformer windings 6 in the electrical transmission system may be placed in circular channels 7 in the outer cylindrical surfaces 21 of the nipple 1 and coupling 3 (Figures 18-20). The parts of the outer cylindrical surface 21 of the adjoining tubes 2 and 4 behind the circular channels 7 from the tube join 22 are linked to an additional outer magnetic circuit 23. Figure 18 indicates a version in which the outer diameter of the outer magnetic circuit 23 is greater than that of the adjoining tubes. Figure 19 shows a version in which the outer diameter of the outer magnetic circuit 23 equals that of the adjoining tubes.

A third version is possible, with the outer diameter of the outer magnetic circuit less than that of the adjoining tubes. Figure 20 indicates a transmission system in which the transformer windings 6 are wound around internal closed circular magnetic circuits 15 and the assembly is positioned in the channels 7 in the outer cylindrical surfaces 21 of the nipple 1 and coupling 3. Here, the outer element 23 must consist of electrically conductive material.

A version is suggested in which the transformer windings 6 of the electrical transmission system are positioned in the circular channels 7, which are on the inner cylindrical surfaces 24 of the nipple 1 and coupling 3 (Figures 21-23). Here, the sections of the inner cylindrical surface 24 of the adjoining tubes 2 and 4, behind the circular channels 7 from the tube joint, are linked to an additional magnetic circuit 25 placed within the tubes. Figure 21 indicates a version in which the inner diameter of the additional magnetic circuit 25 is less than the inner diameter of the adjoining tubes. Figure 22 indicates a version in which the inner diameter of the additional magnetic circuit equals that of the adjoining tubes. Figure 23 indicates a version of the transmission system similar to that in Figure 20. Here also, the additional magnetic circuit 25 must consist of electrically conductive material.

The electrical conductors in the transmission system may also take the form of metallic strips 26 strengthened by flexible ribbon 27 (Figures 24, 25). Here, the flexible ribbon 27 is insulated from the surface 28 of the tube 4, and also insulated from the inner cavity of the tube or the outside (where the ribbon is positioned on the outer surface of the tube) by a covering 29.

To examine the principle of activity of the system proposed, it is permissible for the tube 2 to contain a supply unit, a command production unit and an information-processing unit, and for the tube 4 to contain a sensor unit.

The supply (energy), in the form of alternating current passed at a frequency *f* through the electrical conductors 8, enters the transformer winding 6 fixed in the nipple 1 (Figure 1). In the second transformer winding 6, fixed in the coupling 3, is an alternating current that goes to supply the sensor unit, passing through the conductors 8 situated in the tube 4.

If the tubes 2 and 4 consist of magnetic material, the two windings 6 shall form a transformer with ferromagnetic core. If the adjoining tubes consist of non-magnetic material, the two windings 6 shall form a transformer without magnetic circuit (aerial transformer).

The unconnected magnetic circuits 14 form, together with the windings 6, a transformer with ferromagnetic core (Figure 4), regardless of whether the adjoining pipes consist of magnetic or non-magnetic material.

The closed circular magnetic circuits 15 form, together with the windings 6 and the conductive nipple 1 and the coupling 3, a transformer with a short-circuited screw (corpus) (Figure 5).

Information passed from the sensor unit to the processing unit as an alternating current signal or impulse signal follows the same route as the supply voltage, but in a reverse direction.

Information passed from the command-processing unit to the sensor unit as an impulse signal follows the same route as the supply voltage.

For simultaneous transmission of information on supply voltage and other information, the frequency *f2* of the information signal in the form of alternating current must differ from the frequency *f1* of the supply voltage, or else the information signal must take the form of impulses.

The number of loops in the transformer windings 6 of the linked tubes 2 and 4 may be identical or different. If the numbers of loops differs, the transformer produced by the windings 6 may increase or decrease the supply voltage, and increase or reduce the information signal. When information and energy are transmitted simultaneously, the transformer windings 6 in the adjoining tubes may be sectional, thus producing a transformer that increases both the supply voltage and the information issued by the sensors, with the help of the windings.

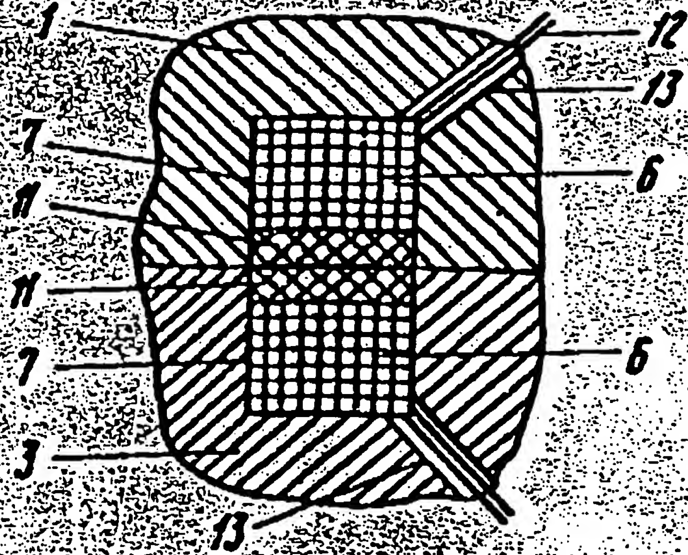
The transmission system proposed may be used either for two tubes in a column or for several successive connected tubes in a column.

FORMULA OF THE INVENTION

1. A SYSTEM FOR TRANSMITTING ELECTRICAL ENERGY AND DATA WITHIN A COLUMN OF ADJOINING TUBES, containing electrical conductors positioned along the body of the tubes, and non-contact communication elements positioned on the nipple and coupling of the adjoining tubes' lock, distinguished in that the non-contact communication elements produce a transformer the primary and secondary winding of which are positioned in circular channels, positioned respectively on the nipple and coupling of the adjoining tubes.
2. A system as per 1, distinguished in that at least one of the transformer windings is positioned inside an internal unconnected magnetic circuit, in which case the body of the adjoining tubes may consist of non-magnetic material.
3. A system as per 1, distinguished in that the transformer windings are wound around an internal closed circular magnetic circuit, in which case the body of the tubes may consist of non-magnetic material.
4. A system as per 3, distinguished in that the circular magnetic circuit of one or both tubes is placed inside the circular closed conductive core, whose unconnected ends protrude above the adjoining surface of the tube, and the body of the tubes consists of non-conductive material.
5. A system as per 1-4, distinguished in that the circular channels are on the butt of the coupling and the supporting surface of the nipple.
6. A system as per 1-4, distinguished in that the circular channels are on the conical threaded surfaces of the nipple and coupling.
7. A system as per 1-4, distinguished in that the circular channels are on the butt of the nipple and the opposite surface of the coupling.
8. A system as per 1, distinguished in that the circular channels are on the outer cylindrical surfaces of the nipple and coupling, and the sections of the outer cylindrical surface of the tubes that are behind the circular channels and away from the join are additionally joined by an outer magnetic circuit, in which case the outer diameter of the outer magnetic circuit may exceed, equal or be less than the outer diameter of the adjoining tubes.
9. A system as per 1, distinguished in that the circular channels are on the inner cylindrical surfaces of the nipple and coupling, and the sections of the inner cylindrical surfaces of the adjoining tubes that are behind the circular channels and away from the join are additionally linked to a magnetic circuit placed in the tubes, in which case the inner diameter of the magnetic circuit may exceed, equal or be less than the inner diameter of the adjoining tubes.
10. A system as per 3, distinguished in that the circular channels are on the outer cylindrical surfaces of the nipple and coupling, and the sections of the outer cylindrical surface of the adjoining tubes that are behind the circular channels and away from the join are electrically linked to an additional outer conductive coupling placed within the tubes, in which case the outer diameter of the coupling may exceed, equal or be less than the outer diameter of the adjoining tubes.
11. A system as per 3, distinguished in that the circular channels are on the inner cylindrical surfaces of the nipple and coupling, and the sections of the inner cylindrical surface of the adjoining tubes that are behind the circular channels and away from the join are electrically linked to an additional outer conductive coupling, in which case the inner diameter of the coupling may exceed, equal or be less than the inner diameter of the adjoining tubes.
12. A system as per 1-11, distinguished in that the electrical conductors are positioned and fixed in grooves located along the length of the tubes, in which case the grooves may be on the inner or outer cylindrical surface, or on both the inner and outer cylindrical surface, of the tubes, and the conductors and transformer windings are insulated by a compound.

Here follow Figures 1-25

Author: S. Konovalov, Editor: S. Kulakova, Technical Editor: M. Morgenthal, Proofreader M. Kul'.



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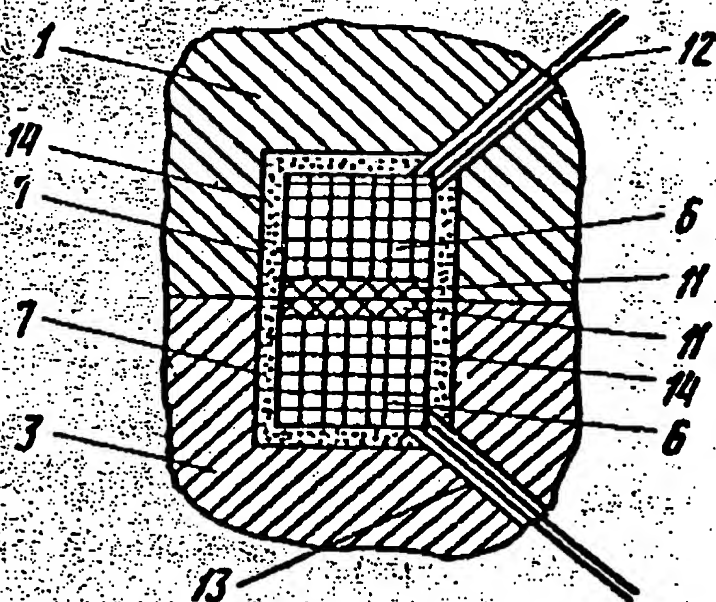

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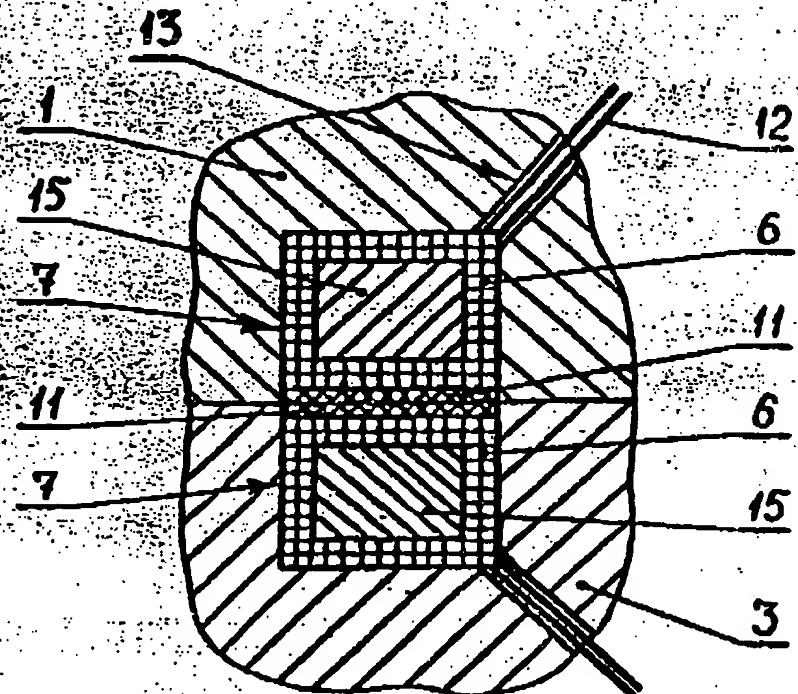

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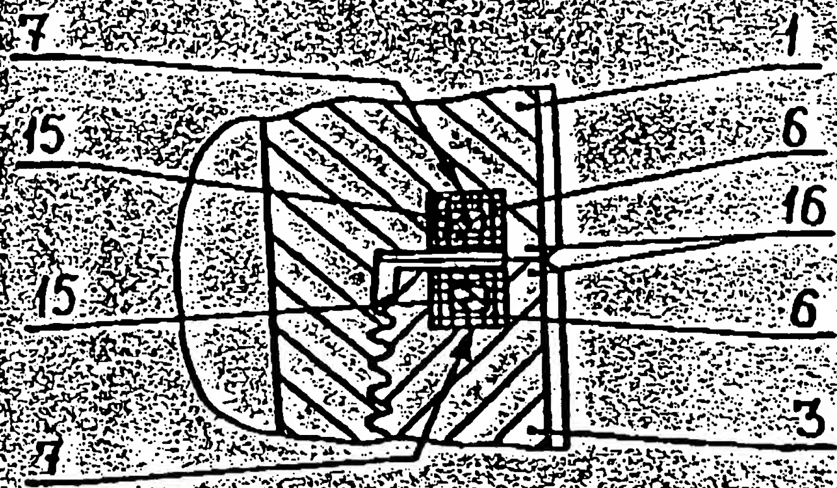

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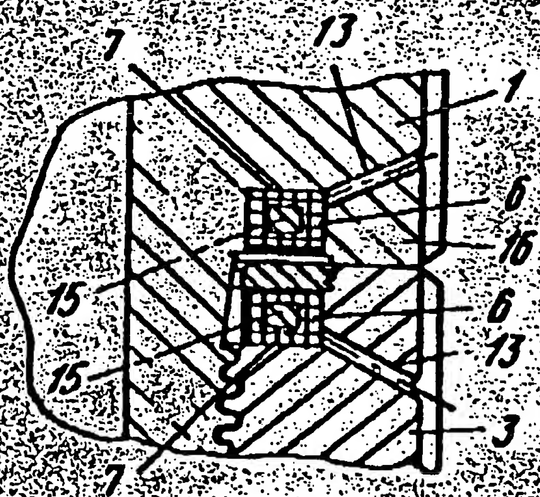

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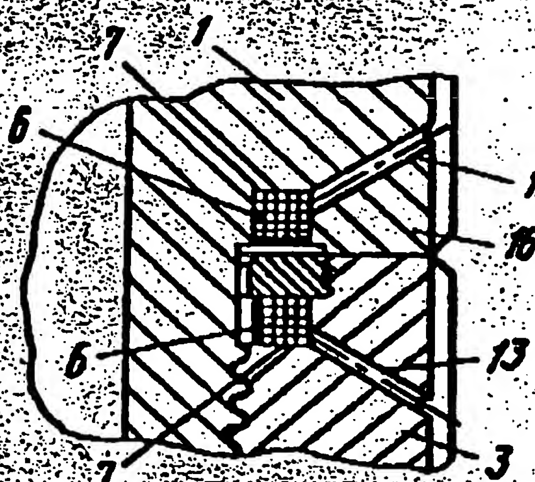

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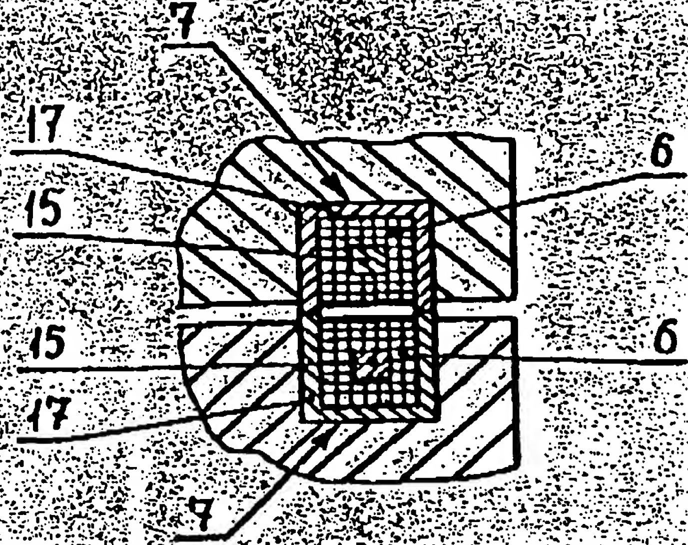

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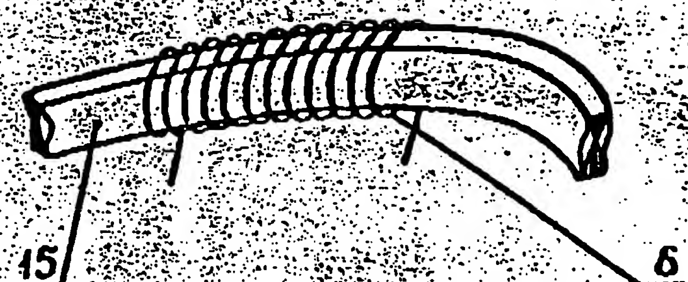

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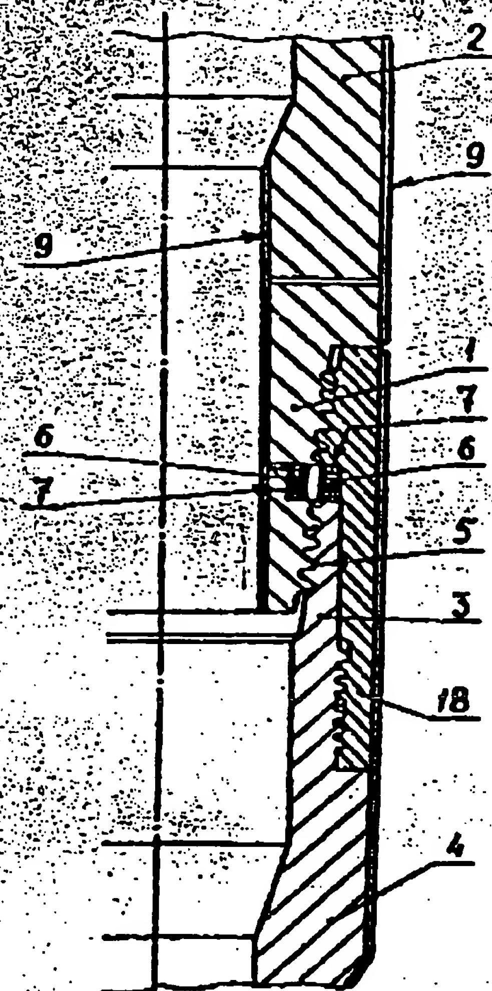

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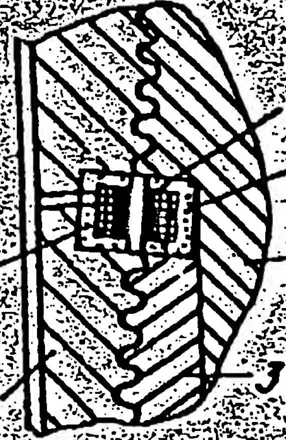

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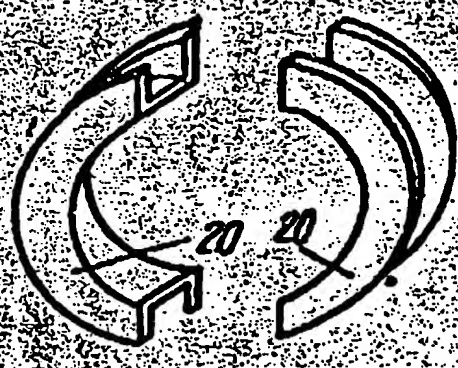
Фиг.13



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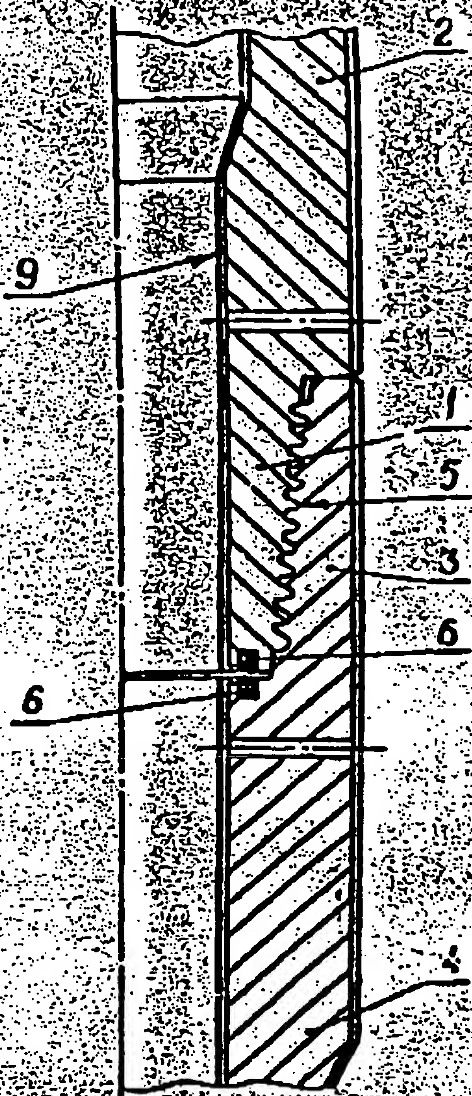

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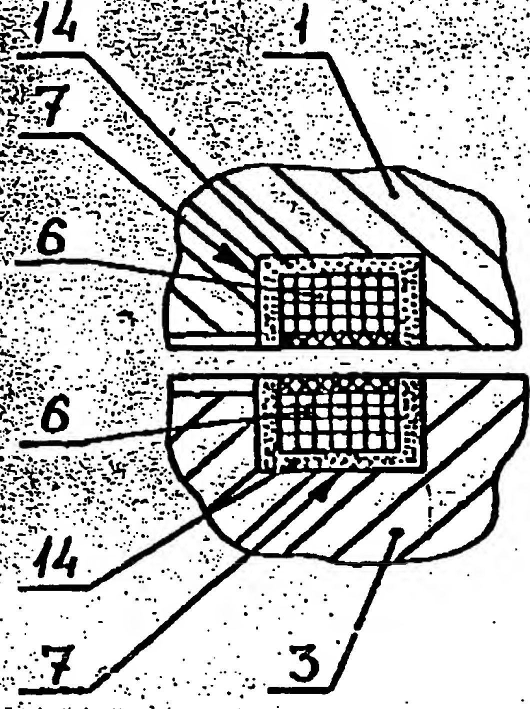

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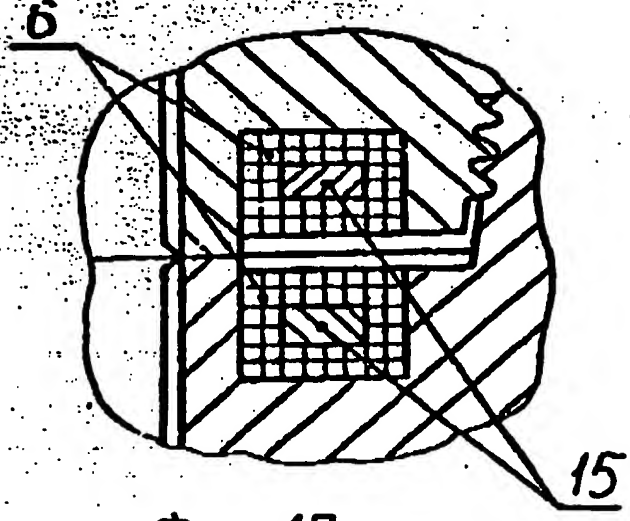

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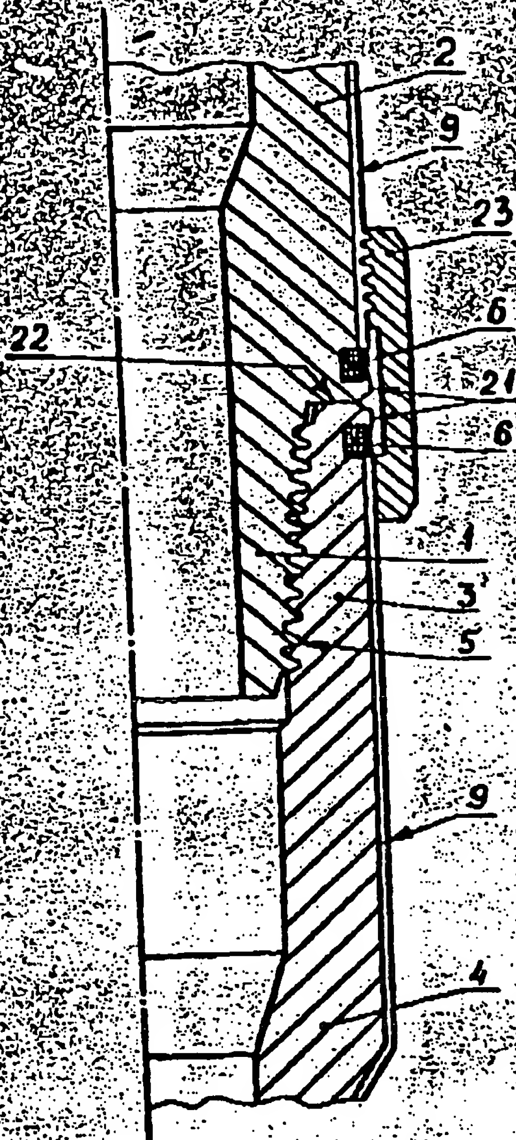

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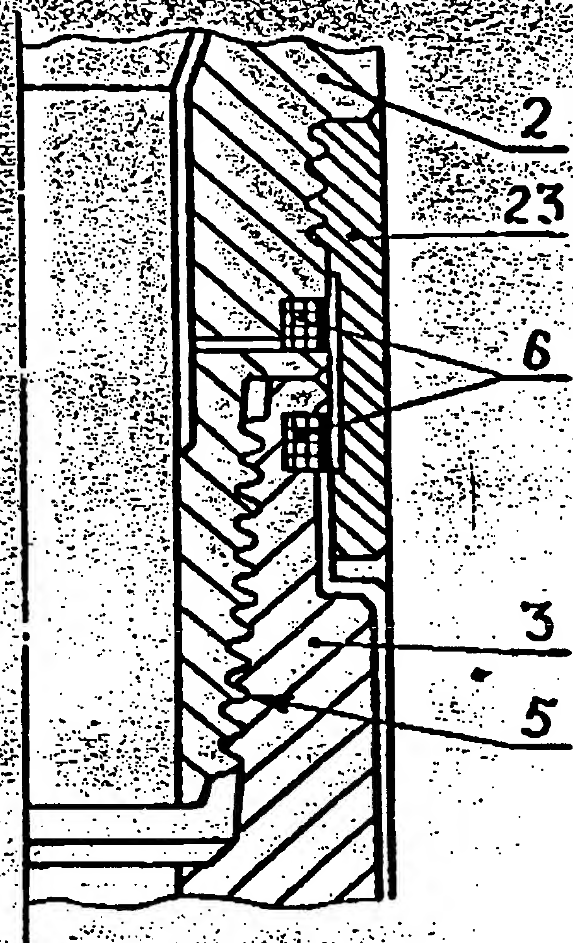

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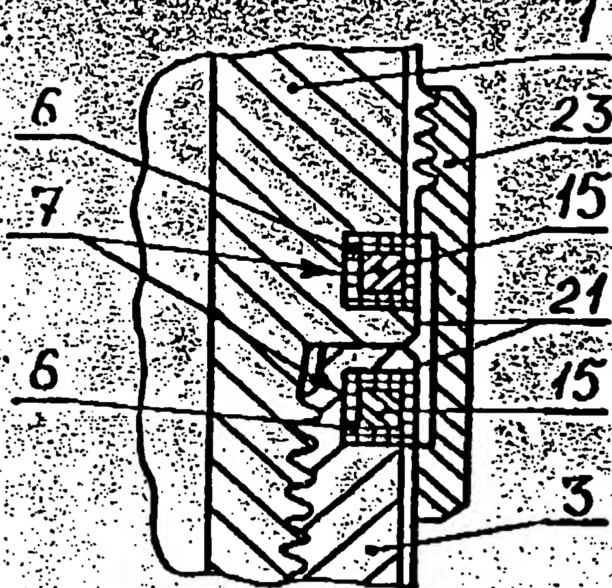

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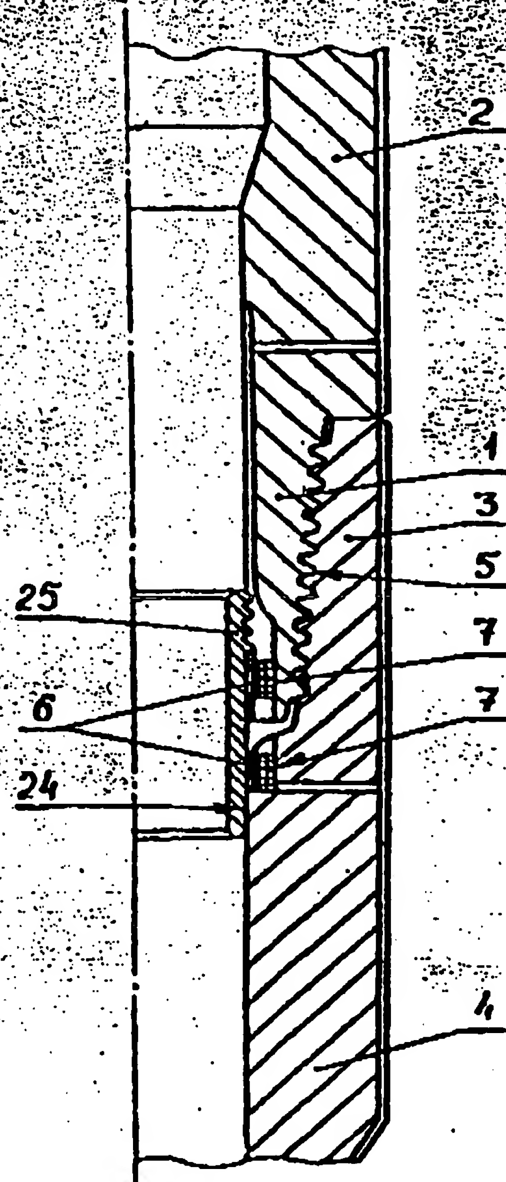

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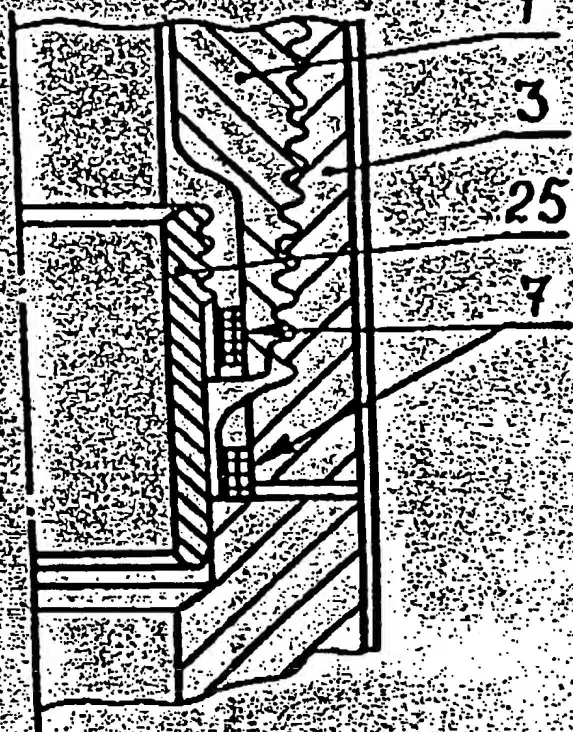

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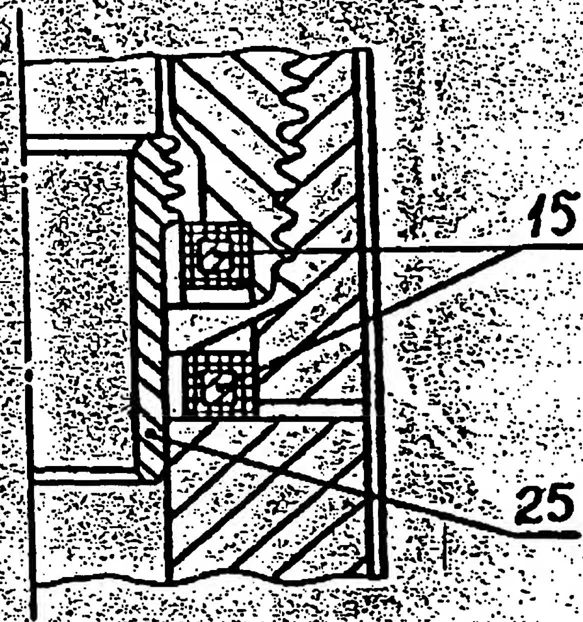

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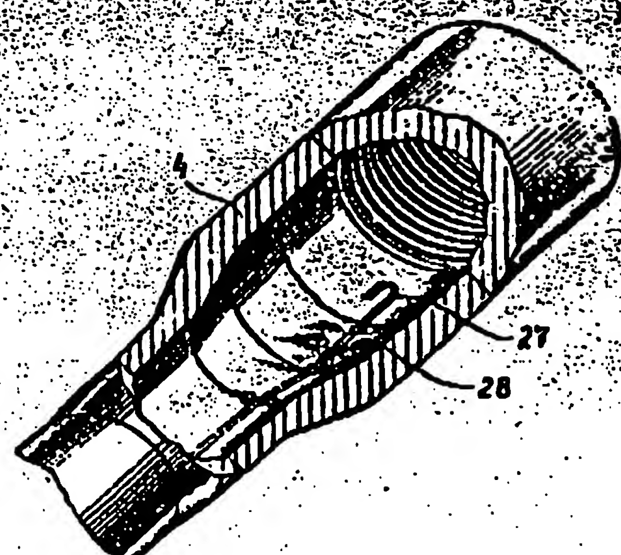

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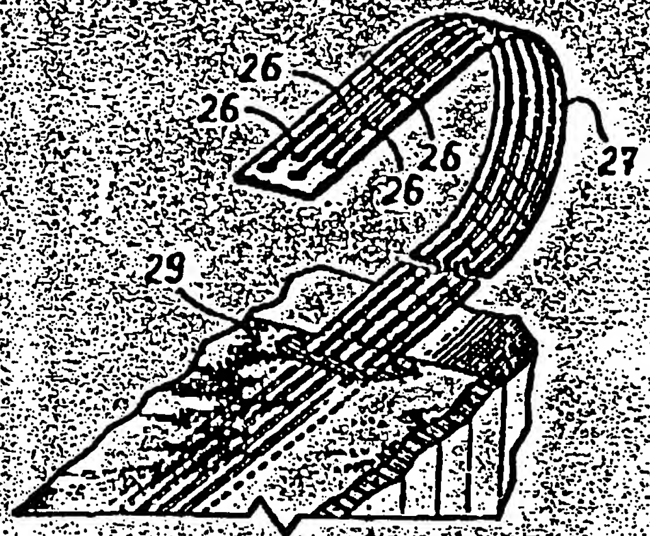

Фиг. 25

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